REMARKS

The Examiner's continued attention to the present application is noted with appreciation.

In the first section of the Office Action dated February 25, 2005, the Examiner objected to the drawings as being informal. Applicant hereby submits corrected drawings.

In the third section of the Office Action, the Examiner rejected claim 6 under 35 U.S.C. § 112, second paragraph, as being indefinite stating, in section 4, that the term "weight classes 6-8" is a relative term, the specification does not provide a standard for ascertaining the requisite degree, one of ordinary skill in the art would not be reasonably apprised of the scope of the invention, and the weight classes could change which would render the claim indefinite. Applicant respectfully disagrees.

On page 1, lines 15-16, of the specification, Applicant notes that the present invention is disposed in a DOT class 6, 7, or 8 truck. On page 10, lines 3-4, Applicant provides an example in which the present invention is disposed in a model W900 Kenworth truck, which is understood in the field to be a Class 9 truck. That terminology is not relative, but understood in by the ordinary person in the art to be a classification of trucks by the U.S. Department of Transportation. Attached hereto as Exhibit A are copies of industry web pages illustrating the understanding of the ordinary person in the art with regard to DOT weight classifications. With regard to a change in the classes, it is understood by the ordinary person in the art that the Class 6, 7, or 8 referred to in the present application is that used at the time of filing the present application. Therefore, the language in claim 6 is not indefinite. Notwithstanding that the meaning of claim language is interpreted in light of the description, Applicant has amended claim 6 to clarify that the recited weight classes are DOT weight classes.

In the sixth section of the Office Action, the Examiner rejected claims 1 and 2 under 35 U.S.C. 102(b) as being anticipated by Lucas, Jr. (U.S. Patent No. 5,186,650). That rejection is traversed.

Lucas, Jr. does not disclose a drawer. Also, Lucas, Jr. does not disclose a file cabinet. The element identified as (26) is a bin (See Lucas, column 2, line 38). Because, Lucas, Jr. does not anticipate claim 1, claim 1 is patentable. Claim 2 is patentable as it is dependent on claim 1.

Amendments to the Drawings:

The attached sheets of drawings include changes to Figs. 1a-8. The sheet containing Figs. 1a and 1b replaces the original sheet that included Figs. 1a and 1b. The sheet containing Figs. 2, 3a, and 3b replaces the original sheet that included Figs. 2, 3a, and 3b. The sheet containing Figs. 4 and 5 replaces the original sheet that included Figs. 4 and 5. The sheet containing Fig 6 replaces the original sheet that included Fig. 6. The sheet containing Fig 7 replaces the original sheet that included Fig. 7. The sheet containing Fig 8 replaces the original sheet that included Fig. 8.

In Figs. 1a-8, all numbers have been substituted with numbers in type font. In Figs. 1a and 1b, wording has been added to indicate that those figures depict prior art and dashed lines have been removed from Fig. 1a. Fig. 3a has been moved to comply with margin requirements. In Fig. 4, dashed lines have been deleted. In Fig. 8, irregular lines have been made solid.

Attachments: Replacement Sheet
Annotated Marked-Up Drawings

In the seventh section of the Office Action, the Examiner rejected claims 1, 2, 7, and 8-11 under 35 U.S.C. 102(b) as being anticipated by Hoffman et al. (U.S. Patent No. 6,386,612). That rejection is traversed in light of the present amendments to the claims.

First, Hofmann does not disclose a file cabinet. Second, as amended, claim 1 recites that the seat is a front seat. Hofmann discloses a rear seat and states that the scope of the invention is for use with the split rear seat (See Hofmann et al., Abstract, first sentence; column 2, lines 56-58). In light of the amendment to claim 1, the "adjacent" seat of claim 2 can only be a front seat. Therefore, claims 1 and 2 are patentable. Regarding claims 9 and 10, Applicant respectfully submits that Hofmann et al. do not disclose the use of elements (20), (22), or (26) as table tops. Further, claims 7-11 are patentable as they are dependent on claim 1.

In section 9 of the Office Action, the Examiner rejected 3, 4, 5, 6, 15, 12-14, and 16-20 under 35 U.S.C. 103(a) as being unpatentable over Hofmann et al. That rejection is traversed. With regard to claim 3, the Examiner sates that it would have been obvious to have a drawer that opens toward a vehicle operator and that the motivation would have been to allow access to the cabinet without opening the vehicle doors. With regard to claims 4 and 5, the Examiner stated that it is well known to provide elastic netting for storage and to include small compartments. With regard to claim 6, the Examiner states that it would have been obvious to provide a cabinet for any class vehicle, the motivation being to provide additional storage. Regarding claim 15, the Examiner states that it would obvious to provide for fasteners in the drawers, the motivation being to store papers.

First, as noted above, Hofmann et al. neither discloses a device for use under front seats nor a file cabinet. Combining it with what is "known in the art" cannot be done to yield the present invention. Hofmann teaches away from the present invention.

With regard to other prior art, the Examiner does not cite to any, instead making conclusory statements about what is known in the art and what is obvious. Moreover, the Examiner submits as motivation no prior art, but rather the problem to be solved. Both the suggestion to make the combination and the reasonable expectation of success must be found in the prior art. *In re Vaeck*, 947 F.2d 488, 493, 20 USPQ2d 1438 (Fed. Cir. 1991); *In re Sang-Su Lee*, 277 F.3d 1338, 1344-45, 61 U.S.P.Q.2d 1430 (Fed. Cir. 2002) (holding that conclusory statements relating to combinations of prior art is insufficient).

Finally, regarding claims 12-14 and 16-20, the Examiner sates that vehicle activated locks are well known in the art. Again, the Examiner cites to no prior art and appears to ignore that claims 13-14 and 16-20 claim more than a lock on a drawer.

Therefore, Applicant submits that the Examiner has not made a prima facie case for obviousness.

In view of the above remarks, it is respectfully submitted that all grounds of rejection and objection have been traversed. It is believed that the case is now in condition for allowance and same is respectfully requested.

If any issues remain, or if the Examiner believes that prosecution of this application might be expedited by discussion of the issues, the Examiner is cordially invited to telephone the undersigned attorney for Applicant at the telephone number listed below.

Respectfully submitted,

By: ______________________
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Customer No. 005179

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Appl. No. 10/762,068
Amdt. Dated May 25, 2005
Reply to Office Action of February 25, 2005
Annotated Marked-Up Drawings

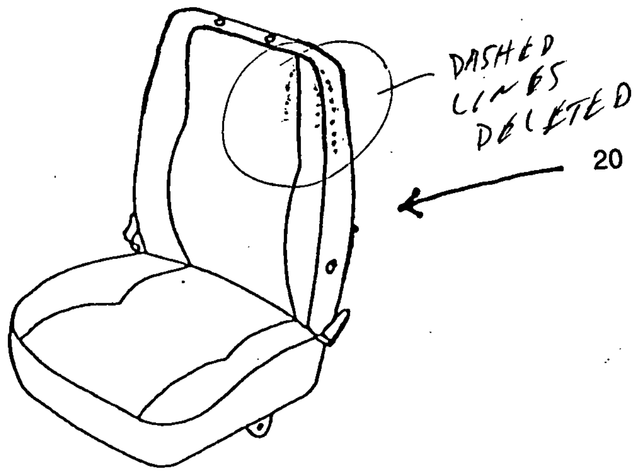


Fig. 1a

(PRIOR ART)

ADDED WORDING

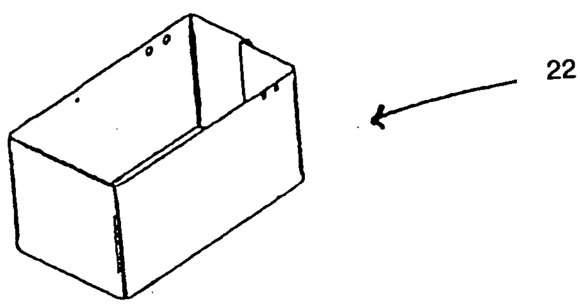


Fig. 1b

(PRIOR ART)

ADDED WORDING

Annotated Marked-Up Drawings

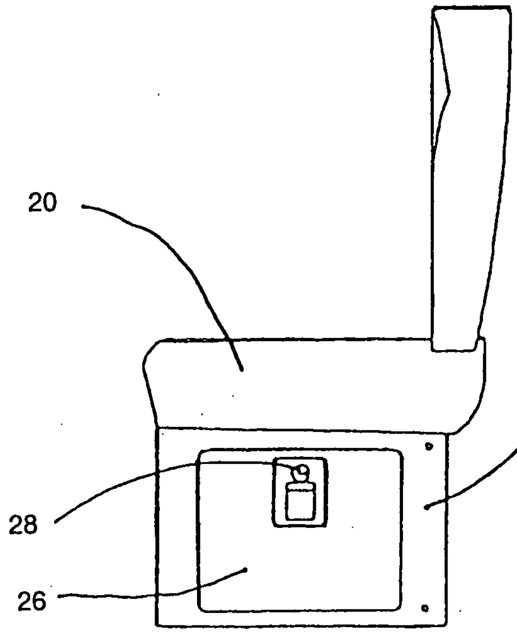


Fig. 2

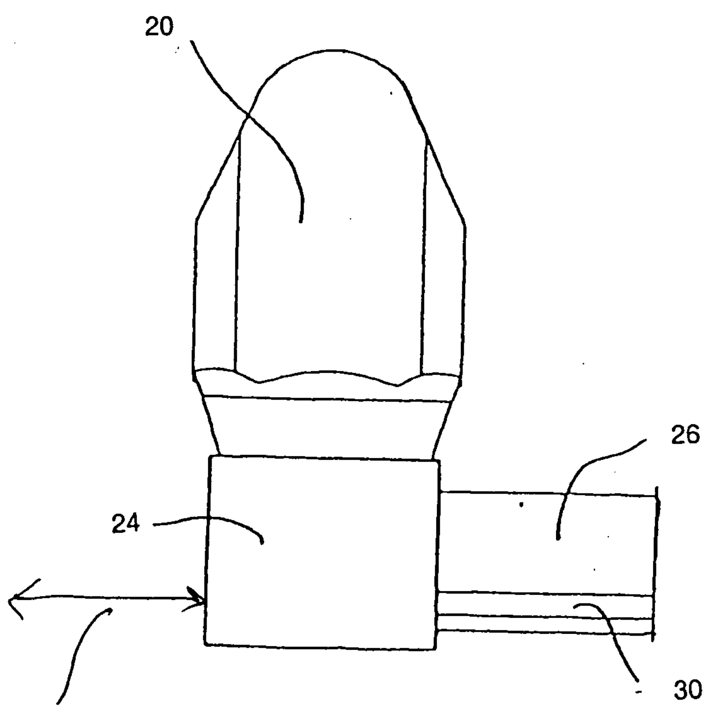


FIGURE MOVED

Fig. 3a

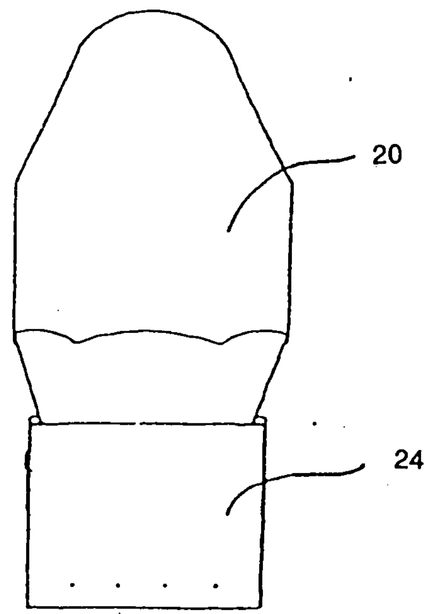


Fig. 3b

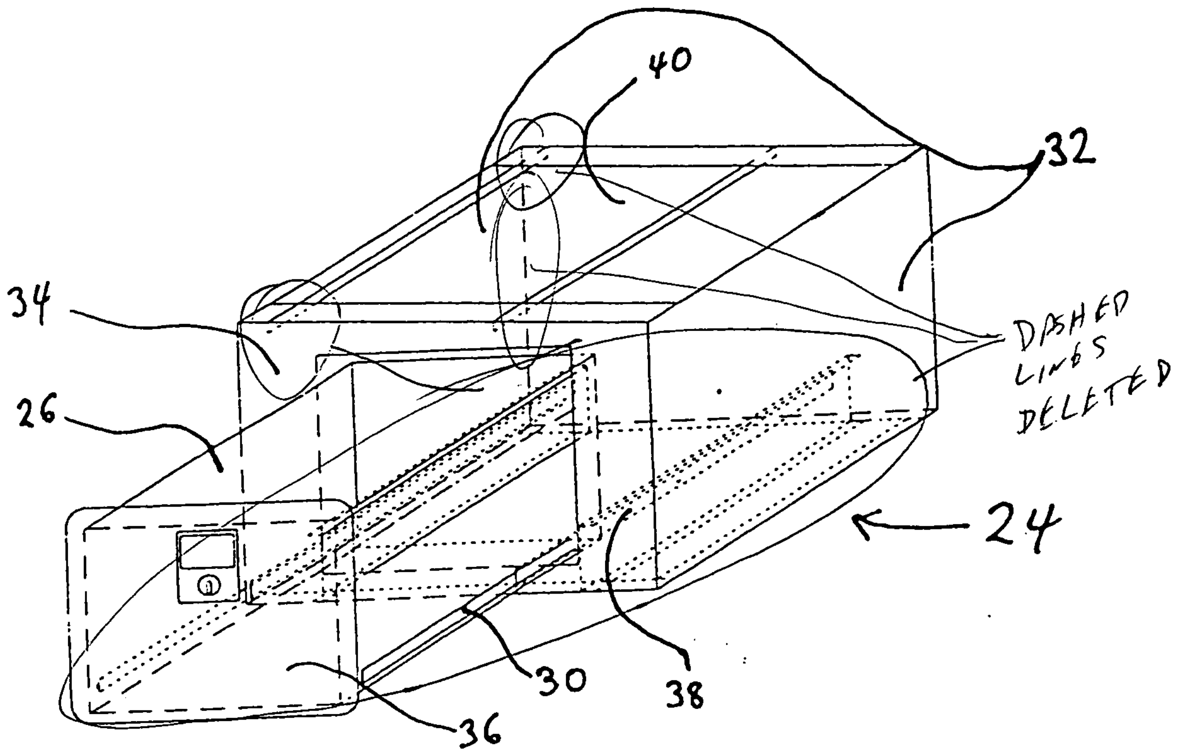


Fig. 4

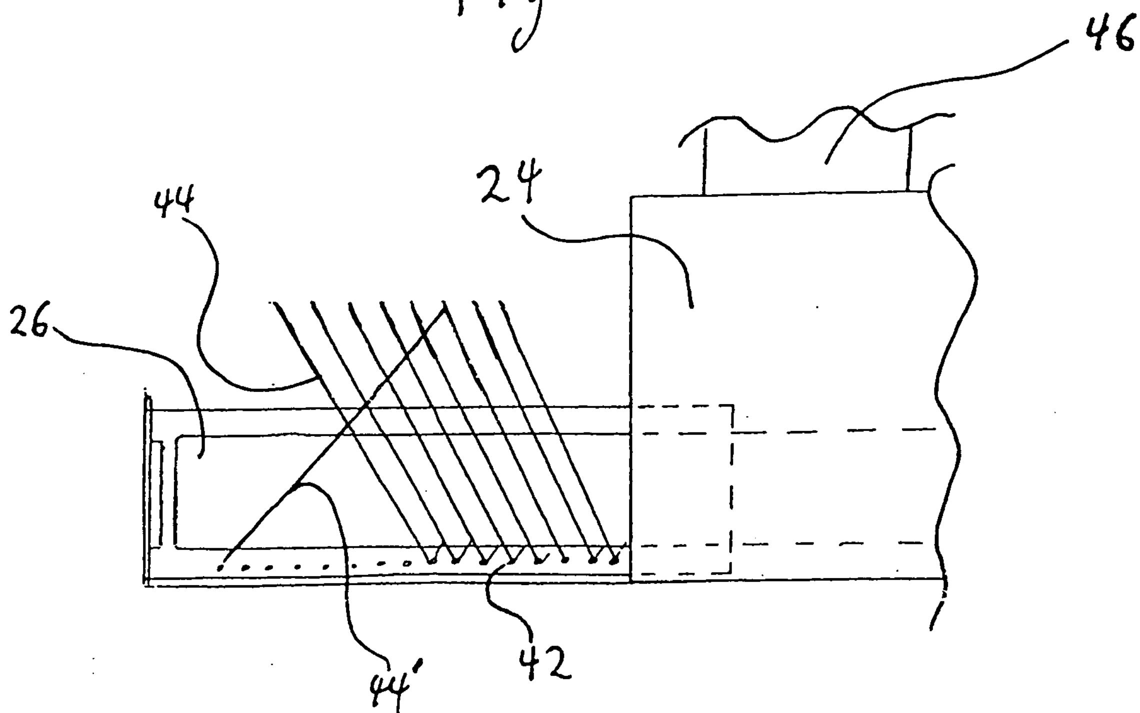


Fig. 5

Appl. No. 10/762,068
Amdt. Dated May 25, 2005
Reply to Office Action of February 25, 2005
Annotated Marked-Up Drawings

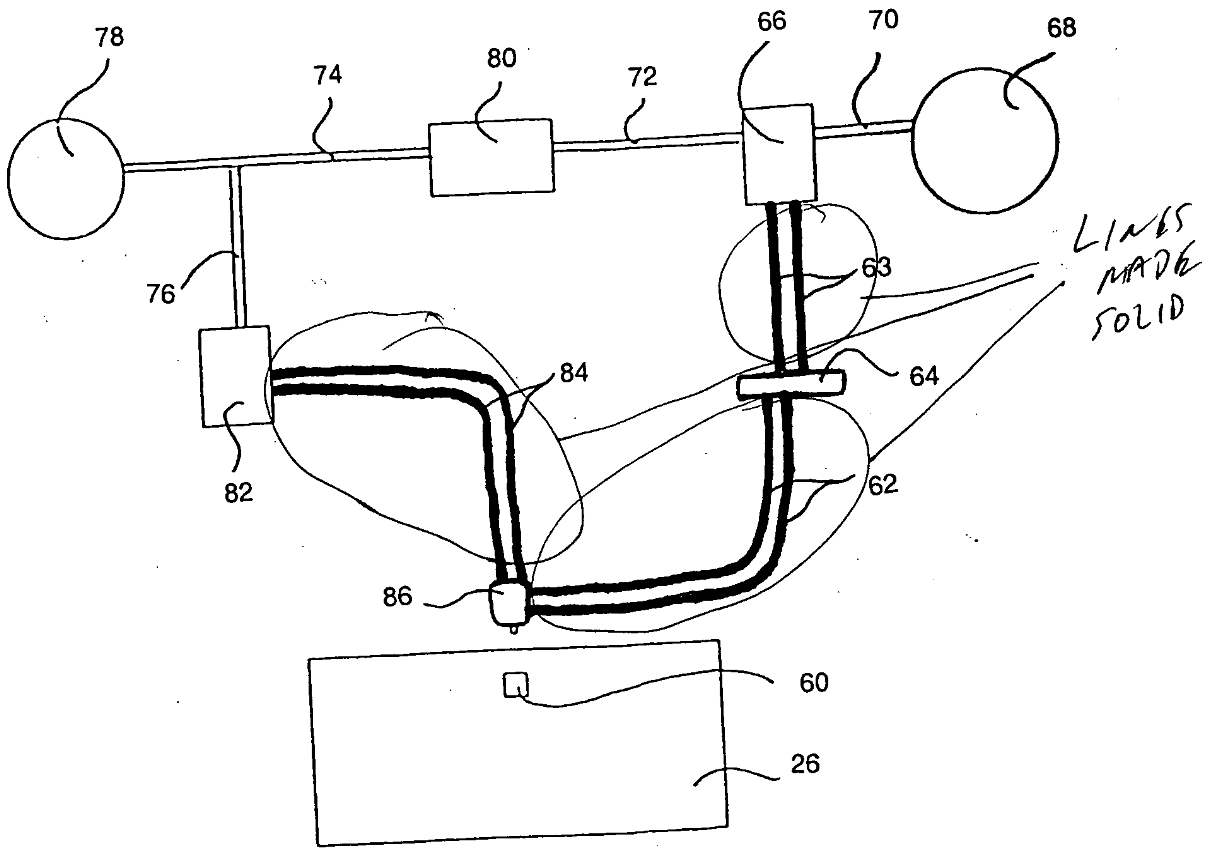
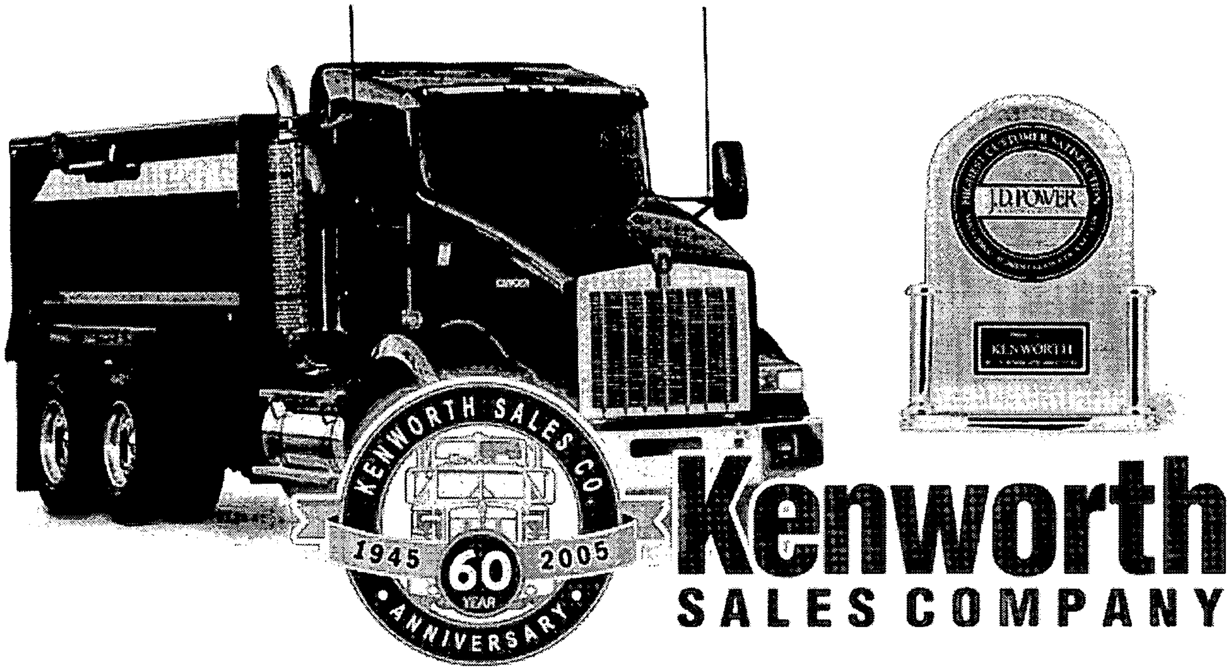


Fig. 8

Home

Idaho Falls, Idaho | Lewiston, Idaho | Pocatello, Idaho | Missoula, Montana | Las Vegas, Nevada
Price, Utah | Salt Lake City, Utah | St. George, Utah | Pasco, Washington | Spokane, Washington



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J.D. Powers Awards Kenworth Industry's Highest Honor - Again!

For the second time in its 2-year history of recognizing Class 8 vehicles, the prestigious J.D. Power and Associates Customer Satisfaction award has honored Kenworth Truck Company! Past honors included the sturdy medium-duty T300, and 2003's heavy-duty Pick Up & Delivery Segment. 2004's honor adds the Heavy Truck Vocational segment, according to the study released August 26, 2004. The award is a genuine reflection on Kenworth quality, reliability and performance. Customers gave Kenworth products top ratings over competitors' products in all 5 exterior categories including ease of serviceability, curb weight, visibility, easy of entry/exit, fit & finish, as well as interior, engine, and ride/handling/braking. Kenworth customers receive outstanding dealer support from nearly 300 North American locations and Kenworth's 24-hour PremierCare customer assistance center at 1-800-KW-ASSIST. The J.D. Power and Associates study was based on interviews with primary maintainers of 2002 model year vehicles.

Kenworth SALES COMPANY

Idaho Falls, Idaho (208) 525-8334	Lewiston, Idaho (208) 746-7087	Pocatello, Idaho (208) 232-1230
Missoula, Montana (406) 721-2760	Las Vegas, Nevada (702) 399-2424	Price, Utah (435) 472-3428
Salt Lake City, Utah (801) 487-4161	St. George, Utah (435) 688-8000	Pasco, Washington (509) 542-0138
Spokane, Washington (509) 534-2643		

Peterbilt

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Company

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Who We Are

Peterbilt ... The Class of the Industry

On highways, construction sites, city streets, logging roads - everywhere our customers earn their living - Peterbilt's red oval is a familiar symbol of performance, reliability and pride.

With our full line of Class 6-8 trucks, proven array of TruckCare aftermarket support programs and respected network of independent North American dealerships, Peterbilt continues its legendary industry leadership.

Driven to satisfy the unique needs and job challenges of our customers, Peterbilt custom manufactures each truck to customer specifications. And whether the order calls for a fully-appointed owner/operator truck or a unit spec'd to fleet requirements, each is manufactured to the same critical quality standard.

Peterbilt's conventional models, for example, feature a precision-tooled, lightweight aluminum cab, a variety of suspension systems for a smoother, quieter ride, and a three-piece, 20-bolt crossmember/gusset unit for extra frame durability. The combination of premium quality and custom manufacturing results in highly efficient, long- lasting trucks that adapt to a wide range of applications and markets. Most important, Peterbilts are the preferred truck of drivers. And fleet owners often cite their purchase of Peterbilts as a way they attract and retain quality drivers.

During the past several years, Peterbilt has introduced more new products and services than at any time in its history - trucks and sleepers that appeal to a broader range of industries, with more options, safety components and comfort features than all other trucks in their class. Additionally, customers are provided the best in aftermarket support through the Peterbilt Dealer Network and Peterbilt's TruckCare services. The latter features a full range of services that includes 24-hour roadside assistance and scheduled maintenance programs for fleets and owner/operators.

Peterbilt has reigned as America's premium quality truck manufacturer since the company's founding in 1939. Our dedication to deliver products and services focused on improving customers' performance, image, profitability and peace of mind truly makes Peterbilt the Class of the industry.

PACCAR Inc

About Us

As a multinational technology company, PACCAR manufactures heavy-duty, on- and off-road Class 8 trucks sold around the world under the Kenworth, Peterbilt, DAF and Foden nameplates. The company competes in the North American Class 6-7 market with its medium-duty models assembled in North America and sold under the Peterbilt and Kenworth nameplates. In addition, DAF manufactures Class 6-7 trucks in the Netherlands and Belgium for sale throughout Europe, the Middle East and Africa and distributes Class 4-7 trucks in Europe manufactured by Leyland Trucks (UK).

PACCAR manufactures and markets industrial winches under the Braden, Gearmatic and Carco nameplates and competes in the truck parts aftermarket through its dealer network.

Finance and Leasing subsidiaries facilitate the sale of PACCAR products in many countries worldwide. Significant company assets are employed in financial services activities.

PACCAR maintains exceptionally high standards of quality for all of its products: they are well-engineered, are highly customized for specific applications and sell in the premium segments of their markets, where they have a reputation for superior performance and pride of ownership.

PACCAR Corporate Contact information

USED TRUCKS: Maximizing Value

BY SEAN KILCARR, SENIOR EDITOR

Mar 1, 2003 12:00 PM

Matt Pain buys only used trucks for the longl business. The reason is simple: they cost fa managed correctly, some can perform almos price of one new truck, I can buy two or thr vp-operations for Pain Enterprises.

The Bloomington, IN-based company, which and liquid carbon dioxide products, maintain 155 straight trucks. Straight trucks are purchased new, but tractors are purchased used.

The key to this decision, says Pain, is that today's Class 8 tractors are designed to run for a million miles. Since the fleet typically buys used trucks with between 200,000 and 300,000 miles on them, they have many more years of good service before major maintenance is needed. "Most diesels don't need overhaul until 700,000 miles, so we might get another 300,000 to 500,000 miles out them before that expense comes due," he explains.

Those advantages can vanish, however, if used trucks aren't maintained properly, Pain says. Mike Moss, Fort Wayne Truck Center, agrees. "You can run a used truck to one-million miles if you buy one with good specs and if it's well-maintained. You can get near new truck performance if you take care of it."

How well fleets manage and maintain used equipment is more critical than ever, now that supplies of late-model/low-mileage Class 8 vehicles have diminished. Several factors have led to this dramatic alteration of the used truck landscape during the past year. Many fleets decided to hold onto their equipment for several more years rather than take a loss on the reduced trade-in value. And the bargain basement prices encouraged others to buy used rather than new.

Demand also increased because some fleets wanted to avoid buying new trucks spec'd with engines modified to meet the stricter emissions regulations that went into effect last October.

Mike McColgen, truck remarketing development manager for Volvo Trucks North America, says demand for late-model/low-mileage used Class 8 tractors was so high that prices actually went up rather than down.With late-model/low- mileage units rapidly disappearing from the market, fleets have to find ways to make units with higher mileage work cost-effectively. One solution is to make sure there's a support package behind the vehicle.

For example, Pain Enterprises chose Kenworth Truck Co.'s PremierCare Managed Maintenance program last year to support its fleet — primarily Kenworth T600 and T800 tractors — in the field. One benefit of the program is that prices for preventive maintenance, as well as work that needs to be done on the road, are determined up front. This is critical issue for used trucks, which require more service as they age.

"We are spread over 14 midwestern states and have to rely on outside garages for maintenance," Pain explains. "Each of our trucks is driven between 85,000 and 120,000 miles a year; maintenance costs were jumping through the ceiling."

Pain uses a specialized software system to track costs for each truck in the system. "For preventive maintenance, I pay a set fee each month that is entered online. Any repair work beyond that is billed to me directly

and I enter it online to keep track of costs," he explains.

Warranties, however, may be the real key to insuring the value of used trucks. "For owner-operators and small fleets, it's always wise to buy a warranty package," says Steve Nadolson, chairman of the Used Truck Assn. "Some fleets may have their own shop network or a deal with a truck OEM's network to cover repairs. But a warranty package helps you get the most value out of a piece of used equipment."

Nadolson explains that the purpose of a warranty is to protect the fleet in case of a catastrophic failure. For example, an engine piston repair can cost up to $6,000 and a total diesel engine replacement as much as $14,000, he points out.

Volvo's McColgen agrees. "As you move up in terms of fleets size, warranties become less of an issue. There's more focus on the price of the truck," he says. "The guys operating one to five trucks, however, have less stomach for risk. For them, it's a combination of issues: the vehicle's performance characteristics in relation to the warranty package they can obtain."

Volvo sells used trucks through its Generation 2 program, which has a variety of warranty options. McColgen says the crucial time period for the small-fleet used truck buyer is the first six months. They must be able operate a used truck for six months without a catastrophic failure so the vehicle can earn money for them.

Volvo's Generation 2 used trucks come with a standard 6-mo./60,000-mi. basic warranty on the engine, with optional 12-mo./100,000-mi. and 24-mo./200,000-mi. warranty packages. The warranties apply to engines because transmissions and rear axles on Class 8 trucks have original 750,000 miles warranties.

Used truck dealers are also offering new options for used truck buyers to encourage demand. Freightliner's SelecTrucks subsidiary, for example, has a fair market lease program called Selectlease that's designed to lower the monthly equipment cost of used vehicles to the end user. "This is part of a broad sweep of offerings — from warranties to finance options," says Bill Gordon, president of Freightliner LLC Market Development Corp.

Gordon says used truck buyers want warranty packages and broad dealer networks for maintenance support on a par with what new truck buyers get. "Support is the big advantage — it helps fleets manage their vehicles better." he says.

That support may become even more critical as low-mileage/late-model equipment becomes scarce and fleets are forced to contemplate buying trucks that have logged more time on the road.

Getting them ready to $ell

How do you get the most money from the trucks you want to sell? FLEET OWNER got some tips from the experts — leasing companies and dealers that sell used trucks for a living.

Maintenance records

Leasing giant Ryder System, which sells thousands of used trucks every year, says having a complete maintenance history for each truck is vital to keep it moving. "One-owner vehicles, with a complete history of maintenance care ... means there is no guessing about their condition," they point out.

Specs

John Bender, corporate used truck manager for Kenworth of Tennessee, says specs greatly affect a vehicle's residual value. "Horsepower and gears sell. There is heavy demand for engines that can be upgraded to 500 hp. or higher. The average premium for 500- to 550 hp. is $3,200 to $3,400. You also want 13- or 18-speed transmissions. That option adds $2,700 to the value of a 2001 Class 8."

Late-model/low-mileage

Over the last few years, many fleets decided to hold onto their older trucks because of falling residual values. This year, however, may be the time to sell late-model/low-mileage equipment: demand is high.

Attention to details

Andrew Krivenko, used truck manager for Wheeling Truck Center, says the little things really matter when selling used trucks. The Volvo dealership first runs e equipment through its maintenance shop, changing all the fluids and filters, replacing sleeper beds, burnt-out lights, checking the vehicle mechanically from top to bottom, to make sure it is so clean the buyer can't tell it from a new truck.

"If there isn't a good warranty left, we'll work with National Truck Protection and put an extra warranty on it based on dynamometer testing." The dealership also guarantees that the truck will pass all DOT weight scales and checks on the initial trip home. That level of detail makes it easier to sell trucks with 500,000 miles on them.

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On-Board Weigh-in-Motion of Class 8 Trucks Using Newton's Second Law

By
Darryl H. Phillips
AirSport Corporation

ABSTRACT

A technique to compute vehicle weight (GVW or GCW) solely from measurements of force and acceleration taken onboard the tractor is described. A means to measure both variables by a single inexpensive sensor is disclosed, and algorithms are presented. Methods to compensate for real-world variables such as wind and grade are discussed, as are results obtained during 20,000 Km of testing. A potential means to determine GCW onboard the tractor without any additional hardware is presented. Applications, including ITS, are discussed, as are methods for instantaneous calibration.

INTRODUCTION

Since 1994, AirSport has been developing on-board Weigh In Motion (WIM) technology under contract to the Federal Highway Administration. The task has been to keep everything on the tractor, with no equipment nor modification required on the trailer. This allows complete freedom of tractor-trailer interchangeability. Potential applications for a relatively low-cost means to find Gross Combination Weight and axle-group weights include: Intelligent Transportation System automated clearance to bypass weigh stations at mainline speed; cargo theft detection; and improved brake proportioning.

Our technique to find GCW relies on the fundamental relationship between force, mass, and acceleration, as stated in Newton's Second Law:

$$Mass = \frac{Force}{Acceleration} \qquad (1)$$

By accurately measuring force and acceleration it is possible to determine mass, which is equivalent to weight for our purposes . We have achieved this using a single inexpensive digital sensor. Of course the devil is in the details, the intent of this paper is to discuss a number of the problems and solutions we have encountered in using Newton's second law to find the weight of a Class 8 vehicle.

ON-BOARD VERSUS IN-PAVEMENT WIM

Weigh In Motion can be divided into two broad categories depending on whether the equipment is on the vehicle, or in the roadway. Each has it's advantages. An in-depth comparison is beyond our scope, but there are a few points that should be noted.

A major difference that may not be readily apparent involves the number of data samples that are available. As each axle passes over a sensor in the pavement, one weight reading is made. For multiple readings, multiple sensors are required. On the other hand, equipment located on the vehicle has the opportunity to make thousands of individual weight determinations and can more easily integrate out errors and noise. Even in a perfect system, any individual measurement is subject to errors due to vehicle dynamics, so the ability to make a great number of such measurements is advantageous. On the other hand, in pavement WIM is able to make axle-by-axle measurements directly, while systems located solely on the tractor require a second (and perhaps a third) sensor to resolve axle group weights.

On-board WIM is potentially very cost effective, theoretically the raw data already exists on the tractor today. Acceleration can be accurately measured in either the tractor ABS or in the engine/transmission ECU. Instantaneous force is rather more difficult, it is questionable whether fuel flow is a sufficiently accurate analog of torque, but there are alternative means of determining force. When these problems have been addressed, it is possible that on-board WIM can be accomplished within existing hardware and the cost will involve nothing more than the software.

Other potential advantages of on-board weight measurement include roving or automated monitoring of weight regulation compliance, the ability of the vehicle to monitor it's weight and report any unanticipated change to the fleet dispatcher, and brake control systems that use axle weight distribution to modulate braking more effectively, perhaps leading to increased vehicle controllability and reduced tire wear.

BRIEF HISTORY OF THE PROJECT

AirSport received a Small Business Innovation Research (SBIR) contract from FHWA in 1994. In the initial six month contract we developed the software and hardware, and instrumented two vehicles.

Based on our demonstrated ability to determine GCW solely onboard the tractor, FHWA awarded a Phase II SBIR contract to continue the work. This effort will continue until May of 1998. As of June 1997, more than 20,000 Km of data have been acquired on a Kenworth tractor pulling a variety of trailers in the workaday world. This represents more than a billion individual data points logged.

MEASURING FORCE AND ACCELERATION

We chose to sense instantaneous torque by measuring the twist or windup of the driveshaft. The modified driveshaft consists of the traditional steel torque tube, with a smaller concentric steel tube added. The inner tube is welded to the torque tube at the output end only.

At the input (transmission) end, the inner tube is supported in a bushing centered in the U-joint yoke, allowing only the outer torque tube to twist in accord with the applied force. The inner tube rotates but experiences no torque, thus no windup. The driveshaft supports adjacent aluminum alloy rings, and each ring supports a number of magnets. One ring is fixed to the torque tube, the other is fixed to the inner tube via a yoke arrangement within the U-joint. The magnet rings, while adjacent, are effectively connected to opposite ends of the driveshaft, bringing the phase of each end of the driveshaft to a common point.

The magnets are arranged in opposition on the two rings, i.e., the north poles face clockwise on one ring and counterclockwise on the other, and the net magnetic field is sensed by a single bistable Hall effect

device supported by the transmission case. As the project has progressed, we have used one, ten, and forty pairs of magnets. More magnet pairs provide increased sensitivity to torque, but the number is limited by the maximum torsional deflection of the driveshaft.

By bringing the relative phase of both ends of the driveshaft to a single sensor, problems of chassis flexing, differences in magnetic sensor sensitivity, and a number of other variables have been eliminated.

As the magnet rings rotate, the output from the bistable Hall effect sensor is a logic-level rectangular wave. The frequency is a function of vehicle speed, while the on-off ratio is a function of applied torque. Thus, on one wire, we have a digital signal that contains the two components needed to find Gross Combination Weight.

DISPOSING OF THE VARIABLES

There are many real-world variables that must be eliminated or at least managed. A short list might include grade, vehicle aerodynamics, road surface condition, tire construction and pressure, internal vehicle friction, engine torque pulses, and a multitude of temperature factors. We have also observed the effects of out-of-round tires, runout in transmission and differential gearing, and more. The list of variables is virtually endless.

To a first approximation, we assume that the variables do not change within a short distance (1 meter). That is, if we take two samples (F_i, a_i and F_{i+1}, a_{i+1}) in rapid sequence, we can assume that grade, et cetera, have remained constant. Therefore, over that small increment of distance, any change in force (F) will produce a change in acceleration (a) that is a function of vehicle weight. The errors in this assumption integrate out to a large extent. For example, the weight error in a sample taken while the grade is increasing will be cancelled by the error in a sample taken while the grade is decreasing. This is likewise true for aerodynamics and other variables that change rapidly. Slower-changing variables such as internal friction or a steady grade are virtually eliminated because, at this time scale, they appear as constants.

The notable exception to the above assumption is deceleration due to wheel brakes, which must be filtered out of the data. On the other hand, deceleration due to engine force contributes to the weight determination. Indeed, we have found the deceleration data every bit as useful as acceleration data.

ALGORITHMS

The gross weight of the vehicle is related to force and acceleration in the following fashion. The slope of a line segment between two successive force-acceleration pairs is shown in (2), where s_i is the slope at the *ith* point in time.

$$s_i = \frac{a_i - a_{i-1}}{F_i - F_{i-1}} \qquad (2)$$

It is also true that s_i is inversely related to mass through Newton's second law, as seen in (3), where m_i is an estimate of mass or GCW obtained from data collected during the *ith* time period.

$$m_i = \frac{1}{s_i} \qquad (3)$$

Our studies have shown that the successive slope estimates, s_i, s_{i+1}, s_{i+2}......, are best combined, not by simple averaging, but by a technique that accounts for both the *vehicle mass* and for the *strength* of each particular sample. Every sample yields a vehicle weight *m*, but some samples are composed of force and acceleration deltas of greater magnitude, and are thus of more importance to the end result.

Let (*VF, VA*) represent a vector whose slope represents the current estimate of the inverse of the weight of the vehicle and whose elements are the current composite estimates of the acceleration and force. Let (F_i, a_i) be a point composed of the ith acceleration and force measurements which are next to be integrated into the composite, let (f_{i-1}, a_{i-1}) be the point composed of the previous time period, and let (*F*, *a*) be the vector that represents the difference:

$$(\Delta F, \Delta a) = (F_i - F_{i-1}, a_i - a_{i-1}) \qquad (4)$$

In order to augment the current force and acceleration estimates with (*F*, *a*), the following algorithm is used. Let *D* be the vector dot product:

$$D = (VF, VA) \bullet (\Delta F, \Delta a) \qquad (5)$$

The new estimate of vehicle weight (VF',Va') is shown in equation 6 where SIGN(D) has a value of +1 if D is positive, and a value of -1 if D is zero or negative.

$$(VF', Va') = (VF, Va) + (SIGN(D))(\Delta F, \Delta a) \qquad (6)$$

A more detailed explanation is found in U.S. Patent 5,610,372.

Since the determination of weight is computed from a large number of small samples, a problem arises when a truck changes weight. In one instance the weight may actually have changed, in another instance a perceived change may be due to short term anomalies. One approach to this situation involves confidence factor, which is described below. In this instance, WIM would continue to report the old weight with a rapidly declining confidence. At the same time, it will be internally building confidence in the new weight. When confidence in the new value exceeds confidence in the old, the reported weight will change to the new value and confidence will continue to improve as time passes. On the other hand, if the perceived change in weight was transitory and not real, the previous weight will continue to be reported with a temporary dip in confidence. After the weight readings re-stabilize at the original value, confidence will return to it's former high level.

ACCURACY

We have found that a GCW error of 2% rms is repeatedly obtainable. This is based on a 36,287 Kg (80,000 lb) full scale. This level of accuracy has included all normal driving conditions including interstate and secondary highways, as well as city traffic. All data has been obtained from the same

Kenworth tractor, using two driveshafts of differing design, and pulling a variety of trailers. On each trip the truck was physically weighed. During these tests GCW ranged from 12200 Kg (27,000 lb) to 38550 Kg (85,000 lb). Under controlled conditions, substantially lower error values are obtainable, and work is proceeding to improve accuracy. The errors in weight computation appear to be a function of errors in acquiring acceleration and force data, rather than any fundamental limit inherent in the technique.

AXLE GROUP WEIGHTS

It is possible to find weights on individual axle groups on a single trailer combination by adding one additional sensor on the tractor (fixed fifth wheel) or two sensors in the case of a sliding fifth wheel. The various weights can be found by employing a pressure sensor to measure air suspension pressure on the tractor driver tandem.

Let W_{gross} be GCW as measured above, $W1$ be weight at the steering axle, $W23$ be weight at the driver tandem, $W45$ be weight at the trailer tandem, $W_{fifthwheel}$ be the weight supported by the fifthwheel, and W_{airbag} be the weight sensed by measuring the air suspension pressure. Further, let the length datum be the steering axle, let $L23$ be the distance to the center of the driver tandem, and let $L_{fifthwheel}$ be the distance to the fifth wheel lateral pivot. Also, when suffixed by *(empty)*, let the above be the measured and stored values taken when the tractor is bobtailed (no trailer). For clarity here, the fuel term has been omitted.

$$W_{fifthwheel}=(W_{airbag}-W_{airbag(empty)})(\frac{L_{23}}{L_{fifthwheel}}) \quad (7)$$

$$W_1=W_{1(empty)}+(\frac{L_{23}-L_{fifthwheel}}{L_{23}})W_{fifthwheel} \quad (8)$$

$$W_{23}=W_{23(empty)}+(\frac{L_{fifthwheel}}{L_{23}})W_{fifthwheel} \quad (9)$$

$$W_{45}=W_{gross}-(W_1+W_{23}) \quad (10)$$

In other words, that part of the gross weight not supported by the tractor axles must, by definition, be supported by the trailer axles. By slightly rearranging the formulae, it is possible to determine tandem weights from a tractor that does not have air suspension by using a load sensor on the fifth wheel.

In the case of tandem axles that share the weight evenly by design, individual axle weight is half of tandem weight. For trailers with split axles, or any situation where there is an inequality in sharing the load between tandem axles, this method will not suffice. In that case it may be necessary to resort to individual axle sensors and power line communications to transfer the data from trailer to tractor.

CALIBRATION

The need for calibration depends on the application. For brake proportioning it may not be necessary to calibrate the weight in engineering units at all. For cargo theft detection, a single calibration at the time of manufacture might suffice since the intelligence is in the unanticipated weight *change* rather than GCW per se.

For ITS purposes, calibration and traceability requirements are more stringent. Verification of performance involves several items, but the final arbiter of calibration and accuracy must be the dead weight scales. Fortunately, we can assume that the truck will occasionally pass over state-operated weigh station scales for verification, and further assume that the ITS system includes a two-way transponder capability for data exchange. Therefore, the on-board WIM equipment should have the benefit of updated calibration received automatically from the weigh station.

The advantage of continual, automatic recalibration bears emphasis. Most measurement systems need periodic recalibration which requires that the unit be taken out of service. This is costly and time consuming. In ITS, the truck (if legal) will usually be allowed to bypass the weigh station, but on a sampling or random basis the truck will be physically weighed. This data from the dead-weight scales can be used to renew and update WIM calibration.

The calibration data comes from the enforcement agency, has traceable accuracy, and has more presumed legal credibility than any calibration from a third party. Since calibration happens invisibly, instantaneously, and automatically, there is no cost or inconvenience penalty to either the enforcement station or to the vehicle operator.

CONFIDENCE FACTOR

For ITS purposes, we believe the weight data should consist of two fields. The first is weight, and the second is something we call "confidence factor". Weight and confidence are somewhat akin to a dimension and a tolerance in a mechanical specification. While the weight field is self explanatory, the confidence number would be composed of several items, perhaps including the length of time since the previous calibration, demonstrated performance over time (i.e., did previous recalibrations require an adjustment in reported weight?), internal estimate of the quality of data presently being reported, and other factors. Of course, confidence is invisible to the operator, and perhaps to the enforcement officer as well.

In this way, a truck reporting a near-limit weight and a mediocre confidence would likely be physically weighed, while a truck reporting a lower weight and moderate confidence (or a near-limit weight and high confidence) would more likely be allowed to bypass the station. As the calibration date ages, confidence will slowly decline and at some point the truck will be re-weighed, providing a fresh calibration. In the Intelligent Transportation System the regulations and algorithms should be intelligent, therefore a truck that regularly hauls heavy loads would be recalibrated more often than a bread truck that never approaches maximum legal weight.

CONCLUSION

Using Newton's second law to determine GCW onboard the tractor with no equipment on the trailer has been shown to be feasible. The data to determine gross weight potentially exists on some tractors today, and will certainly exist as the trend toward increased use of electronics continues. Soon, this technique for weighing trucks may require nothing more than adding the appropriate software to an existing ECU.

At that point, providing on-board GCW capability would be inexpensive indeed. Finding axle group weights involves more sensors and added cost, but can still be accomplished on the tractor for single-trailer operations. Multi-trailer combinations may continue to require power line communications or some other form of data transfer to determine axle group weights.

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We wish to thank Mike Freitas and Dave Gibson of Federal Highway Administration, USDOT, for their enthusiastic interest and support of this project. We also want to acknowledge the SBIR program, which requires that 2% of federal extramural R&D funds be set aside for Small Business Innovative Research. Thanks to that support, this project was possible.

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Heavy Duty Trucking

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International Trucking Show's first stint in Las Vegas drew some 35,200 attendees (preliminary figures), including 22,000 "qualified" (plus 7,500 exhibitor personnel, 3,000 spouses, guests, children). 704 companies exhibited in 262,900 net sq. feet. Comparison: '94 ITS in Anaheim pulled 24,800 qualified attendees; 541 exhibitors in 179,990 net sq. feet. '96 ITS will be May 15-17, again at Sands Expo & Convention Center. Other comparisons: '95 Mid-America Trucking Show in Louisville pulled 52,303 total attendees, including personnel of 835 exhibitors. New England Truck Show in Boston drew record 25,978 (excluding exhibit workers) in 250,000 sq. feet.

Motor carrier revenues up 7.5% 1st quarter '95 but operating expenses rose 7.4% & income dropped 7.5%, says Transportation Technical Services. Higher interest rates & income taxes cut earnings. With signs of economic slowdown, carriers were reluctant to raise rates. Fastest growing expense: equipment rents & purchased transportation (intermodal & owner/operator). Data based on ICC reports by 360 carriers. Contact: (800) 666-4TTS.

Parts sales through June for trailers & Class 6-8 trucks indicate $53 million decline, '94 vs. '95, on annualized basis, says MacKay & Co. Major reason: lower utilization. Trailer utilization is down "significantly," Class 6 & 7 utilization is up some, but Class 8, accounting for over 60% of parts demand, was down 0.2%, June vs. June. Parts sales for heavy duty distributors up 3% through May, according to Council of Fleet Specialists' survey.

Six medium, heavy truck builders form Truck Manufacturers Assn. as liaison with Washington regulators. TMA headed by Bill Leasure, former NHTSA Heavy Vehicle Research Div. chief. Members are Ford, Freightliner, GM, Mack, PACCAR, Volvo GM. Contact: (202) 638-7825.

Trailer shipments through April totaled 101,108, up 44.9% from '94. By type: vans, 81,030, up 50.6%; tanks, 1,717, up 23.7%; bulk commodity, 166, down 15.7%; pole & logging, 431, up 122.2%; platform, 8,315, up 24.6%; low bed heavy hauler, 3,390, up 22%; dump, 3,022, up 13.1%; containers & container chassis, 16,049, down 16.2%. Source: TTMA/U.S. Census Bureau.

Board of Worldway, parent of Carolina Freight Carriers, okays tender offer of $11/share from Arkansas Best Corp., parent of ABF Freight, for Worldway assets. Stockholders have 'til Aug. 11 to accept. Merged ABF & Carolina Freight would be 4th largest LTL carrier behind Roadway, Consolidated Freightways, Yellow Freight. Other Worldway operations: TL carrier Cardinal Trucking; western LTL carrier G.I. Trucking; Carolina Breakdown Service.

Major changes due for all International heavy truck lines within 2 years, says David Johanneson, Navistar group vp-truck business. With finance, labor and corporate issues addressed & several years of "aggressive investment" in new product, Navistar is poised to capitalize on upcoming programs, he says. Company to offer hydraulic antilock standard on midrange trucks by '96.

Johanneson says new truck orders slackening, but "We're not panicking." Current Class 5-8 industry backlog: 60,000. Navistar used truck sales are solid, with dealers getting good prices. It has 900 sales locations, 500 single-line dealers -- 400 of them Class 8 only. Navistar Class 8 forecasts: Calendar '95, 188,000 U.S. retail; 225,000 N. American retail. Calendar '96, 162,000/175,000. Class 6-7, 138,000 in '95; 135,000 in '96. Navistar exported nearly 6,000 trucks last year to countries like Columbia, South Africa, Mexico.

There'll be a major new heavy duty introduction from Kenworth well before the end of the decade. Plans call for more AeroCab introductions including a day-cab, concentration on 112-inch BBC products, new suspensions and electricals. An axle-back AeroCab T800B for Canada will be added; T400 highway truck will be dropped. Says Barry Langridge, Kenworth general manager, "Next year will be our year for new products."

KW's T600A marks 10th anniversary with DOT Award for Advancement of Motor Vehicle Research & Development. The award, for safety, energy & environmental impact, went to design team headed by Larry Orr. Over 70,000 T600s have been sold; there are no plans to discontinue it. In medium duty, KW T300 LNG fuel versions are in production; LNG T800 coming late this year.

The 1992-'94 period saw fastest growth in history for Kenworth dealers, says Lang<\h>ridge. There are now 233 KW dealers in the U.S. and Canada with a goal of 300 by the year 2000. Trend is to multi-service locations, he says, and dealers are increasingly offering contract maintenance. About $^{1}/_{3}$ handle PacLease.

Volvo GM commits $400 million to operations, dealers & new product over next 4-5 years, says Chairman Karl-Erling Trogen. Coming: New cab plant; revamped assembly lines; new truck products in '96-99 time frame. Success of new FH cabover in Europe took Volvo from 12% to 17% market share there.

FH was joint Sweden-U.S. project managed from America. Result: Fuel economy, weight improvements selling well in Europe. Goal in U.S. Class 8 Volvos: move from 10% Volvo content to 25% in couple of years, though 12-liter diesel currently capacity constrained. Company's Class 8 market share target here: 18%.

It will support dealers with extensions to EXCEL used truck program. Retrofit kits for cab windows, side fairings, air suspension to add appeal to used trucks. All used trucks now retailed by dealers. "We're out of the wholesale business," says Keith Hoile, PR manager. Volvo GM has 240 full-line dealers (120 are EXCEL), 100 parts/service centers including Canada, Mexico.

GM will move more low cab-forward production to Janesville, WI. Janesville already builds gasoline-engine NPR-EFI; additional production will be all-new, LCF for Class 6 &7. It will feature Top Kick/Kodiak frame and running gear with mid-sized Isuzu cab introduced in Japan late last year.

GM now offers W5, W6, W7 and W7 HV, paralleling heavier Isuzu F-series models. When production shifts to Janesville, lineup will instead parallel GM products, says Dick Pannell, GMC medium duty manager. Range will include tandem axles, taking the new LCFs into Class 8. Heavier GM products will compete with Volvo FE 64. Debut of Janesville-produced LCF mediums slated mid-'96. They'll also be badged Isuzu for sale through Isuzu distribution.

"North American assembly of the Isuzu F-series is in the works," says Paul Vikner, senior vp-commercial vehicle and engine sales, American Isuzu. He predicts Isuzu F-series sales to jump from 3,083 in '95 to 10,600 in '98. Isuzu has sold 126,000 units in North America since startup in 1984. Combined Isuzu/GM sales targets: 1996 - 23,910; 1997 - 27,660; 1998 - 29,800. Vikner expects continued growth in gas engine NPR-EFI sales: 4,000 in '95, 6,200 in '98. Diesel NPR sales will taper off as gas grows: 14,000 in '95, 13,000 in '98.

Ford's new Louisville/AeroMax trucks aim to save weight, fuel, repair time, says AeroMax Chief Engineer John Sakioka. Due in production later this year, design will take 2 $^{1}/_{2}$-6 hours per truck out of production time compared to L-Series they replace. Weight savings estimated at 500-1,300 lbs. per truck; repair times to be 5%-25% less.

L-Series phaseout slated for fall '96, after 27 years in production and 2 million-plus units. Replacements will be 113-inch BBC Louisville (vocational) & AeroMax (highway) in phase I, then 101 & 122-inch bbc Louisvilles & 122-inch AeroMax in phase II. Integrated cab/sleeper AeroMax will follow a few months later. Included in rollout: customer service technical hotline, emergency

parts program, roadside assistance -- all 24-hour operations.

Freightliner LNG-powered truck, a Business Class FL60, has Cummins B5.9G 195-hp engine, anticipated 5 mpg fuel economy. Range: 500-600 miles. 488 cu in V10 Dodge gasoline engine enters heavy duty service in Freightliner Business Class 5 through 8 models. Rated 300 hp with 450 lbs.-ft. torque at 2,400 rpm, engine option will be available November. Freightliner President/CEO Jim Hebe says 14% of North American medium duty relies on gasoline.

Peterbilt, announcing upgrades in conventional sleepers and lowered cabover at ITS, will also bring out LNG-fueled Model 320 LCF in January. Cummins L10 300G powers it from 135-gallon supply tank.

Rockwell to roll out more new products in next 18 months than previous 5 years, says Larry Yost, Heavy Vehicle Systems president. Coming: steer axles with non-adjustable wheel bearings, lubed-for-life driveshafts, self-adjusting clutches, shift-by-wire transmissions, new air disc brake, simpler & easier-to-fit ABS, electronic braking systems. Future brake systems will go 500,000 miles. Air disc to be available within two years, most others within 18 months.

Prakash Mulchandani, president, North American Truck Systems, says Rockwell plans to grow aftermarket business 50% in 5 years. It's expanding into Mexican aftermarket with partner DeRona. Rockwell aims to be trucking's systems integrator with simple black box to control all processing. On-truck electronics to include flat-panel displays within 3 years. Also promised: integrated global positioning technology, crash avoidance systems. Rockwell also expanding Canton, OH, trailer axle plant. Rockwell do Brasil to supply Mercedes Benz do Brazil with 2-speed drive axles for Class 8 straight trucks.

Refrigeration systems for trucks, trailers to get quieter. Most now around 73 dB; industry aims for mid-60s, says Scott Spaulding, director, marketing & sales, Carrier Transicold. Move to hush reefers follows big push in Europe under new noise regs. Carrier Transicold will improve condenser fan design (borrowing from Pratt & Whitney aircraft technology) and insulation.

The Maintenance Council of ATA votes to sponsor annual light/medium truck show starting with the Fall '96 meeting. Date & place to be determined. Correction: Interstate Truckload Carriers Conference '96 annual meeting is March 17-21 in Las Vegas, not March 20-23 as reported in July Hotline.

People: Clifton Sorrell to director-vehicle management & leasing, Ryder Commercial Leasing & Services, from district manager, Grand Rapids, MI. Michael Delaney to vp-marketing, TIP. Prestone names Rodney Carnes marketing director, Guy Andrysick sales director.

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